

DOCUMENT RESUME

ED 382 456

SE 055 993

AUTHOR Edwards, Thomas G.
TITLE The Use of an Innovative Curriculum: Enabling and Inhibiting Change in Practice.
PUB DATE 8 Apr 95
NOTE 50p.; Paper presented at the Annual Meeting of the National Council of Teachers of Mathematics (73rd, Boston, MA, April 1995).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Case Studies; *Constructivism (Learning); Content Area Reading; Cooperative Learning; *Instructional Innovation; *Mathematics Instruction; *Mathematics Teachers; *Resistance to Change; Secondary Education; *Secondary School Teachers; Student Centered Curriculum; Student Projects

ABSTRACT

Reports on case studies of three secondary school teachers who were implementing the University of Chicago School Mathematics Project (UCSMP) for the first time. The research examined whether innovative textbooks and curriculum materials can play a role in the process of change in instructional practice. Data from field observations, interviews, written journals, and classroom artifacts were collected over two school years in a large northeastern city. It was found that problems with time management and lack of familiarity with UCSMP materials acted to inhibit change. The materials facilitated changes, however, in other ways, including: (1) increased use of cooperative learning strategies; (2) using student reading as an instructional strategy; (3) more mathematical connections being made; (4) a transition toward negotiation of shared meanings; and (5) changing roles for teachers themselves. The author concludes that the changes in teaching practices fostered by UCSMP materials is consistent with a constructivist approach. (Contains 26 references.) (DPM)

* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *

**The Use of an Innovative Curriculum:
Enabling and Inhibiting Change in Practice**

Thomas G. Edwards
Wayne State University

Paper presented at the 73rd Annual Meeting of the
National Council of Teachers of Mathematics
Boston, MA
8 April 1995

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION
CENTER (ERIC)

☒ This document has been reproduced as
received from the person or organization
originating it.
☐ Minor changes have been made to improve
reproduction quality.

• Points of view or opinions stated in this docu-
ment do not necessarily represent official
OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL
IN OTHER THAN PAPER COPY HAS BEEN
GRANTED BY

THOMAS G.
EDWARDS

TO THE EDUCATIONAL RESOURCES
INFORMATION CENTER (ERIC)."

BEST COPY AVAILABLE

A critical problem facing mathematics education today is the translation of the vision of mathematics teaching and learning contained in the two National Council of Teachers of Mathematics (NCTM) standards documents (NCTM, 1989, 1991) into actual practice in our schools. This vision suggests learning environments that are quite different from the lecture-dominated norm that exists today (Goldsmith & Schifter, 1993; Hart, 1991; NCTM, 1991). Clearly some of what Richardson terms "significant and worthwhile changes" in mathematics teachers will be a necessary condition for the realization of that vision (NCTM, 1991; Richardson, 1990). Moreover, "as teachers implement important, timely, and exciting changes, they will require continuing programs of professional support" (Mathematical Sciences Education Board [MSEB], 1990, p. 48).

Ball and McDiarmid (1988) provide a more general rationale for investigating teacher change. They assert that knowing how teachers learn to teach requires a knowledge of how teachers' knowledge bases, skills, dispositions and the interactions among these factors change over time. In a similar vein, Shavelson and Stern (1981) indicate a need for research that links teachers' intentions and their teaching behavior, noting that one justification for such research is the development of "... a sound basis for educating teachers and implementing educational innovations" (pp. 455-456).

MSEB (1990) sees change in mathematics education as an amalgam of many factors, suggesting that, "to improve mathematics education, change must occur simultaneously in curriculum, in teaching, in professional development, in textbooks, and in assessment practices" (p. 48). If this assertion is correct, then an attempt to study changes in teaching practice that occur when teachers implement

innovative curricula and textbooks would provide valuable information about the process of teacher change. As Olson and Eaton (1987) have observed,

Curriculum projects have the often unintended but beneficial effect of asking teachers to reflect upon their practice in a critical way, because, while the materials may have been set up to accomplish certain learning outcomes, working with the materials also affects the way teachers think about their work. We should study those effects of curriculum projects as well as student achievements. (p. 180)

Nelson (1993), in examining the implications of research on teacher change for the professional development of teachers of mathematics, suggests a number of questions for which answers remain opaque. Among these is the role that innovative curricula play in the process of change in instructional practice.

The research reported in this paper examined whether innovative textbooks and curriculum materials, such as the University of Chicago School Mathematics Project (UCSMP) Secondary Component can play a role in the process of change in instructional practice when implemented by three mathematics teachers in a large urban district in the northeast. The problem of change in teachers' instructional practice was examined from a constructivist perspective. If mathematics teachers are viewed as active learners in a continuously evolving problem situation, such an epistemological perspective is viable. Simon and Schifter (1991) simply note that "teachers' learning can be viewed in much the same way as mathematics students' learning" (p. 312). Hart (1991), Shaw and Jakubowski (1991), and Wood, Cobb, and Yackel (1991) all view change in teaching practice as arising from teachers' reflective activity in response to the discovery of some form of dissonance in their

existing practices. It is this sort of impasse-driven learning that renders the constructivist position appropriate as a perspective from which to examine change in teaching practice.

Background

In the 1989-90 school year, a pilot project was conducted in the public schools of a large northeastern city which introduced the UCSMP *Transition Mathematics* curriculum and textbook materials (Usiskin et al., 1989) into the seventh and eighth grade mathematics classes of three teachers. A total of six classes in a single school were involved in the initial project. The researcher was one of those pilot teachers.

For the 1990-91 school year, the UCSMP pilot in this district was expanded to include fifteen teachers in six schools. A total of nearly 500 students in grades 8, 9, and 10 were involved. The textbooks and materials used were *Transition Mathematics* in grade 8, *Algebra* (McConnell et al., 1990) in grade 9, and *Geometry* (Coxford, Usiskin, & Hirschhorn, 1991) in grade 10. During the 1991-92 school year, the UCSMP pilot project in this district was again expanded to include a total of 31 teachers in 11 schools and nearly 1,000 students. In 1992-93, these three UCSMP curricula were implemented district-wide in grades 8, 9, and 10. The following year, a pilot project investigated the efficacy of spreading the study of the *Transition Mathematics* and *Algebra* materials over three years: grades 7, 8, and 9.

Method

The researcher conducted case studies of three secondary-certified teachers who were implementing UCSMP materials for the first time. The data were

collected in thirteen observations that were approximately evenly spaced over the course of two school years. Data sources included field observations, participant teachers' written journals, interviews of participant teachers, and artifacts collected from participants' classrooms. The data were triangulated across both time and source and were analyzed using a constant comparative methodology that attempts to ground results in the ongoing interpretations of the researcher. The data were coded and sorted by keywords. Matrix arrays of the data were also produced to aid in their interpretation.

The strengths of such a methodology lie in the natural setting, which is the direct source of data, and the researcher, who is the key instrument of data collection (Bogdan and Biklen, 1982). When data are analyzed inductively so as to draw meaning from them, and it is this meaning that is of primary interest, the basic premise is that human experience is mediated by the interpretation of meaning (Blumer, 1969). This premise dovetails nicely with a constructivist perspective in which the process of coming to know occurs not through sensory perception directly, but through physical and mental actions on one's environment. But there is also a socio-cultural function that must come into play, for "construction of knowledge therefore is, on the one hand, a result of very general [endogenous] processes, ... and, on the other hand, of the way objects are presented to the subjects with their societal meanings" (Sinclair, 1990, p. 23).

The Case Study Teachers

"Diane," "Gina," and "Kathy" are pseudonyms for the three teachers who were the subjects of case study. Diane and Gina are middle school teachers. Kathy teaches in a high school. All are certified to teach secondary (grades 7-12)

mathematics. The case study of Diane extended over two school years. The studies of Gina and Kathy were for a single year. In each case, the first year of the teacher's UCSMP implementation was studied. A brief description of each teacher and her professional situation follows.

Diane

Diane began teaching with the UCSMP materials for the first time during the 1992-93 school year. She was selected for case study on the basis of the results of a beliefs and attitudes survey that was administered to a group of teachers who were implementing the UCSMP materials for the first time. Her survey responses indicated that she was fairly typical of the group.

In 1992-93, Diane's teaching load consisted of two 8th-grade classes in which the UCSMP *Transition Mathematics* curriculum was implemented and three 7th-grade mathematics classes that did not use the UCSMP materials. The following year, this load was the reverse: three 8th-grade and two 7th-grade classes. Once again, the UCSMP materials were used only with the 8th-grade classes. It should be noted that this district originally chose to implement the *Transition Mathematics* curriculum at the 8th-grade level, although it was written for the upper 85% of American 7th-grade students.

The 1992-93 school year was Diane's fifth year of teaching, all in the same school as a seventh and eighth grade mathematics teacher. The school serves an ethnically diverse student population. The neighborhood in which the school is located is one of the oldest in the city and the signs of urban blight are everywhere. It is within such a setting that Diane spends her professional life.

Diane's professional education, both graduate and undergraduate, was

obtained at a large state university which is also a research center. She holds a bachelor's degree in chemical engineering and a master's degree in mathematics education. Diane is the only teacher with secondary mathematics certification in her school.

Gina

The 1993-94 school year was Gina's sixth year of teaching, all in the same district. It was her fourth year in the school where she now works, which houses more than 1,000 students in grades K-8. There are many ESL students at this school, and the school provides special services for them. Gina indicated that over twenty different languages are represented in the school's ESL program. It is the resulting ethnic diversity which perhaps best characterizes the school.

Gina holds a bachelor of arts degree with a major in mathematics from a small, private liberal arts college located in a nearby city and is certified to teach secondary mathematics (grades 7-12). Currently, she is doing graduate work at a large state university, working toward a master's degree in Teaching English to Speakers of Other Languages (TESOL).

Gina is one of two secondary certified mathematics teachers in her school. She teaches all of the seventh-grade mathematics, while her colleague teaches all of the eighth-grade mathematics. The eighth grade teacher began using the UCSMP *Transition Mathematics* materials in his classes during the previous school year. Gina was part of the pilot project which investigated the feasibility of teaching with the UCSMP *Transition Mathematics* and *Algebra* materials over the course of three years (grades 7-9). She implemented the first seven of the 13 chapters in the *Transition Mathematics* textbook in her classes during 1993-94. Gina's UCSMP

implementation was particularly interesting to follow, given the importance of students reading the textbook in the UCSMP approach, juxtaposed with the large number of ESL students in her classes.

Kathy

Kathy teaches in a grade 9-12 high school of approximately 800 students. The 1993-94 school year was her third at this school, and she has a total of four and one-half years of teaching experience, all in this district. Because much of the research on teacher change has studied teachers in grades K-8, it was particularly interesting to follow Kathy's UCSMP implementation in a secondary school setting.

The school is one of the oldest in the district, the building itself dating from around the turn of the century. Although the building is fairly well-maintained, the rooms are quite small by today's standards. The building is situated in the same neighborhood as Gina's school; perhaps but a five minute walk separates the two.

The school has a reputation in this district as being well-run by a capable building principal. The discipline problems that plague many urban high schools have not been a factor here during this principal's tenure. The student population in Kathy's classes was ethnically mixed, with about 50% minority students. Most of the minority students are African-American; perhaps one-third are Hispanic. A still smaller proportion are of Asian ancestry.

Kathy received bachelor's and master's degrees in mathematics from a small state college with a strong history and tradition of teacher preparation. She often has attended summer workshops. In fact, she attended two different workshops

during the summer that immediately preceded my study of her UCSMP implementation.

During the year that I studied Kathy's UCSMP implementation, her teaching load consisted of three UCSMP *Algebra* classes and two classes that did not use UCSMP materials. The students in Kathy's *Algebra* classes came from all levels from grade 9-12. About one-half were 9th grade students who had studied the UCSMP *Transition Mathematics* course the previous year. On several occasions, Kathy told me that many of her 11th and 12th grade students had already satisfied their district's rather meager mathematics requirement for graduation from high school. This apparently led many of these students to hold an attitude that they did not really "need" the *Algebra* course that they were studying.

Findings

The case studies of Diane, Gina, and Kathy demonstrate some similarities and some differences when viewed across cases. In all three cases, problems with time management in the implementation of the new materials and a lack of familiarity with those materials acted to inhibit change.

The cases of Diane and Gina were the most alike. The ways in which the innovative UCSMP materials seemed to have facilitated changes in their instructional practices were quite similar. These included:

- an increased use of cooperative learning strategies,
- the use of student reading as an instructional strategy,
- an increasing prominence for mathematical connections,
- a transition toward the negotiation of shared meanings, and
- a changing role for the teacher herself.

For both Diane and Gina, the change in teaching role may be characterized as a shift away from a transmitter of knowledge toward a facilitator of learning.

In addition, Gina developed an interest in the use of student projects as instructional devices, as did Kathy. The other changes in Kathy's instructional practices were an increased interest in utilizing technology in instruction and the use of mathematical applications as a focus of instruction.

Each of these cases will be examined in some detail, and evidence for the ways in which the innovative UCSMP materials either facilitated or inhibited change will be presented. These are stories of frustration and exhilaration, of confusion and order, of failed effort and accomplishment. To a great extent, they are stories of professionals in action.

The Case of Diane

During the two-year study of Diane's implementation of the UCSMP materials, the primary change in instructional practice was a movement away from the teacher as a transmitter of knowledge toward a role as a facilitator of learning. Evidence for this shift is provided by Diane's:

- increased use of cooperative learning groups,
- use of student reading as an instructional strategy,
- development of mathematical connections during instruction,
- transition toward the negotiation of shared meanings.

The management of time and unfamiliarity with the innovative materials were the major constraints to change.

Cooperative learning. During our first interview, I asked Diane for her opinion of the use of cooperative learning groups in teaching. She replied,

Well, I guess in my experience, with these students, at least, I haven't come up with a way yet to get them to work in small groups that's productive.

When I probed further to learn whether she might be accept a cooperative learning format, if she could be shown ways to make it work in her classroom, Diane definitely agreed that she would then be willing to give it a try.

During the next five weeks, Diane turned inclination into action. She ended a journal entry with a revealing notation:

In the course of the last three weeks I had the students in the sixth period class doing some group work. ... I'll continue to try this and work at making it more and more beneficial for all. I've also been reading some books on learning teams, and I've signed up for a cooperative learning inservice. I plan to really work at using these strategies in my classroom.

She continued her attempts to implement this strategy, with some success, through the end of the second year of the study.

During an interview late in the first year of the study, I asked Diane if there were any ways in which working with the UCSMP materials had influenced changes in her practice. She said,

I think that through the UCSMP, I started to use cooperative learning more.

That was one thing that I had wanted to do, although I tended to use it more with the seventh grade [her non-UCSMP classes] this year.

A possible reason for her more frequent use of cooperative group strategies in the non-UCSMP classes will become apparent when we examine constraints to change.

Reading as an instructional strategy. Reading is a major component of the UCSMP approach. The UCSMP textbooks were designed to be read by students.

Most, if not all, of the questions, exercises, and problems in these books assume that students have done so (UCSMP, 1989).

The early months of Diane's UCSMP implementation were a period of what she has described as confusion, frustration, and disappointment. A major problem had surfaced in her UCSMP classes: Her students were having grave difficulties reading the textbook independently.

This problem led Diane to seek ways to facilitate her students' attempts to read their textbook. As the year progressed and her students' reading proficiencies seemed to improve, Diane changed her practice to accommodate the changes in her students. Thus, I saw a progression from students reading orally in a whole class format, to students reading individually and silently as Diane modeled some reading strategies for them, to students reading independently outside of class.

The point is that Diane continually changed some of her management routines as she constantly struggled with the problem of her students reading skills. The importance of this, however, goes beyond the mere fact that it is in itself a mark of change. In Diane's view:

The whole reading aspect has entirely changed my way of teaching. I wouldn't think of having my seventh graders [in the non-UCSMP classes] open up their textbook and read it. You know, I wouldn't have in the past. I still don't, really, because I don't see that book as being valuable to read.

However, five weeks after making that statement, I observed Diane do just what she indicated she would not think of doing. The fieldnotes from an observation of her non-UCSMP class late in the first year of the study contain the following description:

They do not finish the lesson. She tells them that there are two other measures of central tendency called the median and the mode, gives them the page reference in their text, and *asks them to read about the median and mode on their own.*

[Ask in the interview if she'd have done that last year.]

When I did ask about that in the follow-up interview, she told me:

I think I have done it in the past, but usually they don't do it. I would do it more frequently now, because of the UCSMP. Definitely.

Mathematical connections. Beginning at about the middle of the first year of the study, there was an unexpected change that Diane noticed, first in her students, and then in herself. It was related to a January entry in her journal:

I liked the presentation of the material in lesson 5-2. Writing the pattern for adding fractions with like denominators was a good carry over from chapter 4. I also liked the way it was tied into the work with measurement.

Later in an interview, Diane attached a label to what she had written about:

I like the way things are tying together and I like ... I like its cohesiveness, you know, that it's connecting things, where I, in the past, teaching the other eighth grade curriculum, had difficulty connecting it in that way. And I think it's connecting it in a neat sort of way, and in an understandable kind of way, as well.

During that interview, Diane also related an incident that had occurred in one of her UCSMP classes:

I had put a pattern for the additive identity, on the board, and I was asking each one of them to give an instance of the pattern, and one of them said, "Can't you do the same thing with 1?" And I said, "Well, what do you mean?" And he said, "Well, you get the same thing with 1." So we kept talking about it and

they were connecting additive identity and multiplicative identity, which I thought was really neat.

By the end of the school year, Diane had noticed that her students were not the only ones who were making new mathematical connections:

I think I always wanted to have ... to be able to make connections better, but didn't always have the resources to do that. Or the time. And this seems like it's - the UCSMP text is laid-out so that it's pretty much right there. I think some of the connections are a result of the reading and the way that it's written. And so I've been taking from that, and seeing myself more connections, and being able to make more connections for the students. I've been noticing that UCSMP has helped me be interested in connecting ideas together more for my seventh graders. I've felt more willing to try to make math apply to their lives.

That the UCSMP implementation was a source of the development of mathematical connections in Diane's practice is clear from the way that development unfolded.

The negotiation of meaning. Wood, Cobb, and Yackel (1991) suggest the negotiation of taken-as-shared meanings as an alternative to teacher-imposed meanings. In this way, the mathematics classroom is transformed into a mathematical community. Simon and Schifter (1991) describe several attributes of such classrooms:

- The teacher is no longer the transmitter of knowledge, but is a facilitator of learning.
- The teacher avoids commenting directly on the correctness of particular student ideas, instead letting those ideas stand or fall on their own merits.

- No longer is the teacher the sole judge of mathematical validity. That role now passes to a mathematics community, of which the teacher is but one part.

My first observations of Diane made it clear that she was the authority for mathematical correctness in her classroom. Whenever I observed a review of classroom or homework exercises, Diane always confirmed student responses with, "Correct," or, "Good!" or some such remark. She was quite sensitive to incorrect or partial responses posed by students and was somewhat accepting of them. Generally, she would open a dialogue so as to guide the student to the "correct" answer. In so doing, it was clear that Diane was imposing her own methods and meanings.

Fairly early in the first year of the study, however, I noticed characteristics of a negotiation process taking shape for the first time. Interestingly, these first steps were imbedded in a lesson that was filled with teacher-imposed meanings as well. The ambivalence of the lesson is exemplified in the following notation from my fieldnotes:

She asks if anyone can explain, *in their own words*, what it means to evaluate an expression. She waits [perhaps 5-6 sec], then 'guides' the class to *the response that she wants*.

Toward the end of the lesson, I noted that:

Diane assigns an example for the students to work on in pairs. They are finishing this task, and she asks one pair to explain their solution, which they do. Now she asks *someone else* to justify those results.

In another class, Diane discussed with her students the key ideas in a lesson

that they were reading together from the text. That discussion led to the following excerpt from my fieldnotes:

The first key idea that they have identified is area. Together, they negotiate a meaning for area. She is quick to use their suggestions, and *they come to an agreement that is not quite the book definition.*

Thus was born the negotiation process in Diane's classroom, in small steps such as these, I suspect.

Although she continued to the end of that first year usually passing judgment on student responses to homework or classroom exercises, I saw a few instances where she did not. Moreover, student responses during lesson segments were another matter indeed, as the authority for correctness subtly changed. This is not to suggest that Diane always instigated a process of negotiation in her lessons thereafter, nor even that she frequently did so, but the fieldnotes from the second half of that first year are littered with the word "negotiate."

A vignette from the non-UCSMP classes demonstrates the depth in which this transition sometimes manifested itself. Diane had her students working in groups of three or four on a review sheet in preparation for a test the next day. In her instructions to them, she was adamant that she would not answer any questions herself about the mathematics content if there was someone in the group who could do so. In fact, I did not hear her answer any such questions. All of her interactions with students during this activity were either motivational or concerned their cooperation with each other. At the end of the class period when the students were once again in a whole-class format, Diane gave them both positive and negative feedback regarding their cooperative skills. The mathematics content was

never mentioned.

The implication of this is quite powerful, I think. The students had negotiated their own understandings of the material. On that particular day, during that particular activity, they were the mathematics experts. This was a radical departure from Diane's past practice.

At the end of the first year of the study, I asked Diane if she was aware of any source for this transition to a process of negotiation:

I think it's probably a result of the UCSMP, in the sense that I'm doing less lecturing with them. So they're having more ownership in learning the material, which causes them to be more interested and to know more. And they're struggling more to have to do it ... it's not just - this is how you do it - that part is gone.

Diane's transition toward the negotiation of shared meanings with her students continued into the second year of the study. As the second year progressed, the nature of the review of exercises in Diane's classes began to change dramatically. Whereas during the previous year, she had provided nearly all of the explanations herself, now I noticed that she began to use questioning techniques so as to draw the explanations from students themselves. I also noticed that she no longer seemed to be validating her students' responses. It is in this area that Diane has shown perhaps the most change, and much of that change seems to have been consolidated during the second year of her UCSMP implementation.

Shift in role as teacher. Central to all of the other indicators of change in Diane's practice is the shift in her role as teacher. My first observations of her practice left me with the impression that here was a teacher whose underlying

philosophy of teaching was the transmission of knowledge through direct instruction. In this model her role was clear: She was the teller; the provider.

I watched that role change, sometimes subtly, as the study progressed. Much of the evidence of this change has already been presented: the use of cooperative learning groups, the use of student reading as an instructional device, the development of mathematical connections, and the transition to taken-as-shared meanings. Two short paragraphs from the fieldnotes of my observations during the second year perhaps best capture the subtle nature of this transition.

I wrote the first of these following a class discussion of one of their homework problems: to find a solution to the equation $x^y = 343$. They had built a table for x , y , and x^y , and they had generated 6 or 7 instances of this relationship.

Diane abruptly brought the discussion to a close, and I noted:

What's interesting here is that she does not continue to a solution. Rather, she tells them that they now have an idea how to do it, and that they are capable of finishing themselves. She indicates that she expects them to continue to experiment and explore with instances until they find a solution.

I wrote the second entry to describe an incident that occurred during a whole-class discussion of a lesson that the students had read the previous night:

They are mostly engaged in the discussion, but when she asks a higher order question (Why do we generalize?), she gets no response. At that point, rather than just tell them, she speaks to them about giving the matter some attention, and then gets one student's idea. When no others are forthcoming, she says she is going to leave that one with them to think about for a while.

Eighteen months earlier, when Diane first began to implement *Transition Mathematics*, such teacher behavior would have been almost unthinkable.

During one interview, Diane told me how the reading component of UCSMP had pushed her to make other changes: changes in her planning, viewpoint, and role. I seized the opportunity to ask just how she thought her role in the classroom had changed:

Now I'm more of a facilitator than a provider, I think.

Constraints to change. As much as the UCSMP implementation appeared to work as an agent of change in Diane's practice, it also provided two main areas of constraint. The first of these was a curriculum management problem.

The pace of the course is a huge constraint, I think. I think it's a constraint to the other aspect we were talking about before where I wanted to put more of my own ideas into what I'm doing, and I think that part of me not being able to do that yet is because of the time constraint.

Apparently, though, Diane saw her experiences in the first year as opening up possibilities for the next:

My only complaint is that there isn't enough time. I want to have some slack, but don't feel there is any slack. I'm already looking forward to next year and time two through this course!

The other constraint to change stemmed from Diane's lack of familiarity with the new UCSMP materials. I asked her to elaborate on journal reflections that indicated frustration and confusion on her part. With a chuckle, she replied:

I guess it's just like traveling down the unknown road. And it feels like having less of a handle on the curriculum aspect for me makes the control, the management, more difficult.

Diane reiterated that theme at the end of the first year. After discussing some of the ways that she saw her practice change over the course of the year, I asked her if she felt that anything had constrained her from making such changes:

The constraint part I see as being mostly because it's new and I haven't done it before and that makes it a little more difficult to change.

In the second year, the experience that Diane gained during the first year somewhat countermanded any lack of familiarity as a constraint to change. However, to a degree, familiarity remained an issue. Toward the end of the second year, in speaking about the UCSMP curriculum, Diane said:

It feels more familiar, but I still feel like it's somewhat of a constraint.

She then indicated that it will take more than just one year to gain a really comfortable familiarity with these materials.

Time, on the other hand, seems always to be a constraint to change. During an interview mid-way through the second year, Diane said:

Overall, I feel more comfortable with it and I think that's my experience, having done it once. But still, many of the things we did last year and many of my feelings about there being a lot to do and about there being time pressure, they're still there.

While it is clear that both of these factors continued to inhibit change in practice during the second year of Diane's implementation, neither seemed to loom as large as during the first year.

The Case of Gina

The findings from the case study of Gina's UCSMP implementation closely parallel those from the case of Diane. The innovative materials constrained Gina from making changes in her instructional practices in the same ways as with Diane. Moreover, many of the changes that Gina did make were similar to those made by Diane. In one area of change where Gina differed from Diane, she began to use student projects as a vehicle for instruction.

Student projects. In October 1993, I attended a Saturday morning UCSMP inservice meeting. I found the format of this meeting to be particularly interesting: teachers presenting instructional ideas to other teachers.

It had been decided by the UCSMP teachers at an earlier meeting that student projects would be a required part of the district-wide final assessments in each of the three UCSMP courses. Therefore, the central theme of this inservice meeting was the development student projects. Six different teachers presented various projects that they had successfully used with students at levels ranging from seventh through twelfth grade.

Gina was in attendance at that meeting, and she apparently took the presentations on student projects to heart. One week later, she wrote in her journal:

I assigned a "Scavenger Hunt" project using newspapers and magazines.

Students need to cut out examples of certain ideas (an estimate larger than one million, a range of values, numbers written in order, etc.), label each, and display on a poster or in a booklet.

When I visited Gina in early November of that year, I noticed that she had perhaps two dozen of these student projects displayed in her room. She was

somewhat sheepish when I asked her about them, indicating that she was disappointed in their accuracy. Moreover, she believed that many of them demonstrated students' misconceptions regarding the mathematical concepts that the project addressed. Nevertheless, she was upbeat in her assessment of the project and told me:

I decided to find something positive in it, and I think it got them used to the idea of having projects in math [and] of looking for evidence of math in newspapers and magazines.

Gina considered this project to be a qualified success (there were those inaccuracies, after all) and indicated that she planned to use future projects.

When I visited a month later, Gina was planning another project. This one concerned the nature of mathematics among diverse cultures, involved some library research, and incorporated a group structure. Ultimately, Gina utilized this project in the early spring. When I asked her if she had used student projects as a learning device in prior years, she replied:

No, I haven't. I think I might have had them do biographies one year, but I haven't had them do projects like this.

Cooperative learning. Interestingly, just as Diane had, Gina found the use of cooperative learning groups a promising venue in regard to teaching with the UCSMP materials. However, Gina came to this conclusion quite early in the year and found it inescapable. In our very first interview, I asked her how importantly she viewed cooperative learning as an instructional strategy.

In the past I haven't used it, definitely not most of the time, and probably not half of the time. I don't think I'm going to have much of a choice with this

program. I'm just going to have to have them work in groups, just to get as much experience as possible ... because of the pace of the course; because of the whole setup of everything.

In this instance, Gina saw the implementation of a UCSMP curriculum, with its heavy reliance on student reading, as problematic due to the large number of ESL students in her classes. She then decided to use cooperative learning groups, which provide a format for students to utilize each other as resources, as a response to the problematic situation with which she was faced.

Mathematical connections. In discussing mathematical connections, I include connections between mathematics and students' everyday lives, connections between mathematics and other academic areas, connections between mathematics and students' prior knowledge, and connections between mathematical concepts themselves. Although in my baseline observation I did not observe any particular attempt by Gina to help her students form mathematical connections, I did observe some movement in this direction during the 1993-94 school year.

The first reference to mathematical connections that I entered in my fieldnotes occurred during my observation of Gina's teaching in October:

Gina interjects questions in an attempt to point out important parts of the lesson they are reading together. She is clearly attempting to get them to connect the key ideas in the lesson.

On my next visit in November, I noted that:

The focus today seems to be on why standardization of units of measurement is necessary. Gina is connecting the development of measurement with parallel historical developments.

I placed a memo in my fieldnotes at this point to ask Gina during the interview if she had attempted to make such connections in the past. She told me:

No, I hadn't done it really with measurement before. Geometry is where I used to make, more, the historical connections. No, in the past I guess I didn't.

Gina then confirmed my inference that the textbook had been the source of the historical connections that I had seen that day.

Two journal entries that Gina made in December shed more light on this issue. In particular, they suggest that Gina herself views the UCSMP materials as an important catalyst for the increased emphasis on mathematical connections in her instructional practice. Early in the month, she wrote:

I find some of the [textbook] examples (and "Additional Suggestions" in the Teacher's Edition) very interesting. I think this changes how students respond to questions, examples, or introductory activities for some topics. I notice some students seem more comfortable offering comments. They seem so satisfied with themselves to recall an advertisement or something they saw on TV or some athletic statistics - anything remotely connected to what we are learning about.

Later in the month, she reflected on a change that she perceived in her work:

The students' level of participation changes how I do some things. I spend more time with introductory discussions. I see the value in just getting them to talk about math, look at it differently, and make even the most remote connections to their lives and their present knowledge.

Reading as an instructional strategy. Gina recognized early in the year that the large number of ESL students in her classes might become problematic as she

implemented the UCSMP materials. She wrote in her journal:

I'm concerned about reading, especially considering the language problems of the many ESL students. I've used some suggestions to focus more on reading skills with everyone - skimming, finding important words, strategies for answering questions. I know I have to continue stressing these reading strategies in class.

In November, again writing in her journal, she considered the extra "flexibility" that she had as a result of her pilot implementation of only the first seven chapters of the *Transition Mathematics* textbook.

I feel the additional time I have goes toward reading. I'm still covering the reading orally in class and really have no plans to change this.

During the interview in December, Gina told me of a recent discussion she had with her classes:

We talked about how it's different that they have to read. They were never given those reading assignments before.

Clearly, this statement acknowledged that just the process of student reading was a change in instructional format.

However, there was more than mere form to this aspect of change. It is important that Gina's implementation of reading strategies also changed her classroom in substantive ways. A journal entry from November hints at the substance of such change:

We are spending more time *discussing* reading also. Their comprehension doesn't seem adequate, so I realized I have to interject my own comments and *elicit theirs* several times during the reading [emphasis added].

Hence a problem with students' reading comprehension was addressed through

class discussions in a manner that incorporated the exchange of ideas between teacher and students. Such an interpretation fits well with the notion of a transition to the negotiation of shared meaning with students.

The negotiation of meaning. During a baseline observation of Gina, it became clear to me that, while she was a patient, understanding teacher who was accepting of students alternate ways of doing things, she also regarded the teacher as the final authority for mathematical results. This interpretation was based upon her habit of always acknowledging student responses as, "Correct," when they were, or of always providing some clue, such as a voice inflection, when an error had been made. Moreover, during a class discussion in which she asked for the meaning of the word "miscellaneous" and received an acceptable, if not perfectly clear, student response, she ended any possibility of a negotiated meaning by providing all of the examples herself. Toward the end of that baseline observation, I wrote in my fieldnotes that

she clearly is the judge of correctness.

I noted similar tendencies during my early observations of her uses of the UCSMP materials the following school year. Particularly during reviews of homework assignments, it was obvious that the teacher was the authority for correctness. The fieldnotes of my September 1993 visit contain the observation that

she is the mathematics authority in the room.

I also noticed that most, if not all, of the examples that were used in the lessons that I saw in September and October were provided by the teacher or by the textbook. But I also noticed the seeds of change.

During my observation of a *Transition Mathematics* class in September (she had only been using the UCSMP textbook for about two weeks at this point), I watched Gina use a negotiation process to settle a difference of opinion that her students had reached regarding the comparison of -1 and -1.5. It might have been easier to just tell them, and it certainly would have been faster, but Gina took the time to let students express their understandings of inequality and negative numbers. In this way, they were able to resolve this discrepancy themselves.

Later during that same class, she had her students write: "Three numbers can be compared in the same sentence if they are in order." Then she asked,

What do you think I mean by the word "sentence", and, what does "in order" mean?

Finally, she asked the students to generate examples such as $1 < 2 < 3$. Each time, Gina asked,

How does everyone feel about that answer? Do you agree with it?

This was a radical departure from anything I had seen previously.

Further evidence of a transition toward the negotiation of meaning with students can be found in an incident that I observed in one of Gina's classes in January. During the lesson that day, Gina attempted to help her students come to the realization that the calculator, while an efficient tool when used sensibly, can actually become a hindrance when used thoughtlessly. Throughout the lesson, it was easy to sense a spirit of negotiation in her words. When a complex computation generated a variety of student answers, she asked two students who had gotten two different incorrect answers to

put your heads together to see if you can figure out what's going on.

What's happening here?

In the end, the students came to the agreement that sometimes even complex computations can be easier to perform without the technology. She ended the lesson with a student-provided summary of what they had learned.

Fullan (1982, 1991) observes that effective change takes time. Perhaps this is so in the case of instructional practice, because teachers need the time to assimilate the new strategies that they are attempting to employ. Perhaps it is nothing more than old habits that are slow to die. At any rate, Gina's first steps toward the negotiation of meaning with her students did not signal a complete make-over in her style of teaching. Just as with Diane, these were merely first steps.

Throughout my observations of Gina's teaching, I witnessed an ambivalence similar to that which had surfaced in Diane's practice the preceding year. At times Gina instigated a process of negotiation with her students, yet at other times she simply functioned as a "teller," or provider, of knowledge. Often, this occurred during the same class period; sometimes it occurred within the same activity.

For example, Gina discussed with one of her classes the solution to the question, "Find 0% of \$17.50." My fieldnotes contain this description of that exchange:

Gina asks if the answer zero makes sense. They agree that it does, but it is Gina who provides the explanation of why that makes sense. She extends the problem by asking them what 50% of \$17.50 is. She gets one way to do it; then asks if anyone knows another way. When there is no immediate response, she points them in the direction she wants by asking, "What is 50% really equal to?"

Thus it can be seen, within one tiny portion of one class period, that, on the one hand Gina attempted to negotiate meaning through sense-making agreements and alternate methods of solution, while at the same time imposing her own meaning by providing *the* explanation and leading her students in the direction that *she* wanted to take.

Sometimes Gina had an awareness of this transition and consciously took steps in the direction of shared authority. Late in the school year, she described a typical recent event that had occurred during a problem solving unit:

I really emphasized alternate ways of working problems out in the problem solving unit. For any one problem, we might have had three different demonstrations and I'd say, "There's no point in me doing it. I'm sure everyone understands this, because you did it, rather than me getting up and showing you my way of doing it." So we did that sometimes.

When I reflected on Gina's nature as a teacher when I first observed her work some eleven months prior to this interview, such a statement would have seemed totally out of character.

Shift in role as teacher: From source to resource. My interpretation that the changes Gina made in her instructional practice during the first year of a UCSMP implementation had fostered a shift in her role as teacher follows naturally from the nature of those changes. Her movement toward the use of cooperative group work necessarily implies such a shift, as does her transition toward the negotiation of shared meanings with students. Both of these changes tend to restructure learning environments as more student-centered. Both cast the teacher in more of a facilitator's role.

The emergent prominence of mathematical connections in Gina's instruction and the way she approached her students' problems with reading both demonstrated the sort of free exchange of ideas that is often associated with the "teacher-as-facilitator" model of instruction. Over the course of a school year, I watched as Gina became less concerned with her routines and procedures and more concerned with developing greater flexibility in the classroom. As she phrased it in a journal entry,

I think I'm searching for my comfort level with this.

In February, Gina continued to address the issue of a possible role-shift when she wrote:

I do see my role changing this year. In the past I considered myself as the "source" that would demonstrate and model strategies, then give guidance as students practiced things on their own. But now this year, with *Transition Mathematics* I've been re-thinking all of that. I see myself as more of a facilitator and a "resource." My role is to give students the chance to do some exploring and discovering. I like taking the chance to tell students they make better teachers than me very often - that they can explain concepts more clearly to their classmates than I can. I sense myself getting students to think about math in a new way.

Just as I, in a similar vein, sense that Gina has begun to think about teaching mathematics in a "new way."

Constraints to change. Almost from the beginning of the school year, Gina provided evidence that she often felt constrained by time as a direct result of the UCSMP implementation. In her very first journal, she wrote:

I often feel rushed to complete as many of the problems as possible in class. It was easy for me to sense this feeling as I observed Gina's work. My fieldnotes from observations in December provide a typical example:

I can clearly see some attempt to engage students in what I would call a negotiation process, but I also detect a sense of "hurriedness." In one case, she asks for an alternative response, but when what she gets is not quite what she was looking for, she hurriedly explains what that students' thinking had been, rather than asking the student to do that himself.

The issue of time also arose frequently and spontaneously in my interviews of Gina. In December, the following exchange occurred in the interview:

Interviewer: You say that *Transition Mathematics* is more relevant and real to them. Does this change things in your classroom in any way?

Gina: I think so! I think just with the discussions, they kind of take different ... I'm not sure where the discussions are going to go, a lot.

I: Is that a good thing?

G: Yeah! I don't mind that. Although, I probably did mention this, I'm always worried about the time, and the clock, and, you know, things can't get too far off-track.

Later, while we discussed a semantic mapping activity (see, for example, Carrell, Pharis, and Liberto, 1989, especially the examples that are illustrated on pp. 652-653.), she said simply, almost in exasperation:

We need more time!

In a December journal entry, she continued this theme when she wrote:

I just do not allot enough time in a given class for some activities [underlined in original].

Finally, in January, she told me:

I have to figure out how to focus time more.

I interpret this sequence as a struggle to fit change in practice into a context that was charged with pressure to complete a given amount of material within a certain time frame. Gina was determined to make changes, but felt she had to reconcile any such change with the time she felt was available. Moreover, as her own words convey, it can be difficult to institute change while looking over one's shoulder at the clock.

A second constraining factor was unfamiliarity with the UCSMP materials. Gina herself raised this issue as a constraint to change. It appears to be closely related to the time constraint discussed above. In October, while we were discussing time as a constraining feature, Gina complained that

there's a time constraint; I'm watching the clock constantly.

I acknowledged her remarks and asked if her clock-watching was new for her. She replied:

Yes! Because after five years of teaching the same stuff, I kind of knew what they were going to have problems with. I kind of knew which questions would give them a problem. But I really think it's just not having been through it before.

Thus with Gina, as with Diane, there was an uncertainty about "the unknown road" not previously traveled, and that uncertainty acted to constrain changes in practice.

The Case of Kathy

The primary areas of change that I observed in Kathy's instructional practice

were the use of student projects as instructional devices, an interest in utilizing technology in instruction, and a focus on the applications of mathematics. Some of this change was different from that which I observed in the other two cases. Moreover, Kathy's most prominent changes did not seem to derive from her use of the UCSMP materials alone. The changes that did occur - the use of technology in instruction, the use of applications as a focal point of instruction, and the use of projects - while certainly supported by the UCSMP materials, seem rooted at least as deeply in the content of two summer workshops in which she had recently participated. Kathy was constrained from making changes in practice by the same factors that inhibited change in Diane and Gina: lack of sufficient time and unfamiliarity with the UCSMP materials.

Student projects. Kathy spoke of an interest in projects during our first interview in September 1993:

I'd like to get more project oriented, where the kids go home and do experiments - using what they've learned - but in an experimental, project-type form. It's not just doing textbook questions, but getting some real applications.

Given that a workshop in which she participated just weeks earlier had focused on the use of real-life situations, and that at this point in the year she was still relatively unfamiliar with her UCSMP *Algebra* textbook, my guess is that the source of this initial interest in projects was the summer workshop and not UCSMP.

However, UCSMP would tend to support such an orientation, and, as noted in the case of Gina, the teachers in this district using the UCSMP materials had decided that a project would be a required portion of the district-wide final assessments in the UCSMP courses. The project that Kathy first utilized was

developed during the summer workshop. She described the project in the following terms:

We did a project, scatter plots, for *Algebra*. And I wanted some of the kids to try to do one of the graphs on the calculator. But they got so involved in the project that they didn't get to the calculator.

Kathy seemed pleased with her students' responses to the project, noting that:

only a couple of people didn't get it in on time.

When I asked her directly how she felt about the project, her reply confirmed my sense of her satisfaction:

I like it. Next year, I put in for a new Applied Math course, and that's all based on projects. I'm real excited about it!

Utilizing technology. The two workshops that Kathy had attended during the summer immediately preceding her UCSMP implementation both emphasized making use of calculators and computers in the teaching of mathematics. Kathy had a wealth of technology available in her classroom: an overhead projector, a scientific calculator for the overhead, six graphing calculators, a Macintosh computer with an LCD palette for projection on the overhead, and software to emulate a graphing calculator with the Macintosh computer. However, I rarely saw Kathy actually use any of this technology in her teaching, and when I did, it was the scientific calculator on the overhead alone that I saw used. Most of the evidence that I have of such use is second-hand, coming from her journal or our interviews.

In January, she wrote in her journal that

UCSMP has encouraged me to use more technology.

This statement is possibly related to the emphasis on technology that appears

throughout the UCSMP Secondary Component. However, as will be discussed in a later section, Kathy felt constrained from utilizing technology in her UCSMP classes to the full extent that she would have liked.

Kathy apparently felt no such constraint to using technology in her classes that were not using UCSMP materials. During an interview in March, I asked if she had been able to utilize her graphing calculators. Her response indicates that she had used them in her non-UCSMP classes:

I've used the TI-82 with my Course 2 classes [a non-UCSMP curriculum]. I've been doing a lot of graphing with my Course 2s, and I've used the graphing tools I have on the computer to do that, too.

What particularly fascinates me about this response is that the Course 2 classes to which Kathy referred were also a new assignment for her. The curriculum for this course is an integration of geometry, algebra, probability, and statistics and is customarily taught in the second year of high school in this district. The approach is quite traditional. Yet Kathy apparently found the means to use graphing utilities in those classes, but not in the UCSMP *Algebra* classes.

During an interview in December, I verified that Kathy had an overhead calculator that matched the scientific calculators that her students were using, and I asked her how she had been able to utilize it. She told me:

When I'm first doing a new thing, the first thing when I do it, I usually have the overhead out. When I'm explaining a new process, I will have the overhead out.

When I asked during a February interview whether she had made any further use of her overhead calculator, she replied:

There's days where it's a lot of computation. I'll get the calculator out, so the

kids actually see my key-strokes.

During a later visit to her classroom, this was precisely what I observed.

I also asked Kathy to elaborate on her uses of technology, other than the scientific calculators. Her reply described as much promise as action:

Occasionally, I use the computer when I want to do a lot of graphs, to show them quickly. But what I plan on doing is trying to get the graphing calculator implemented in this chapter [on statistics]. Because, I want them to be able to do a scatter plot.

It is reasonable to suggest, as did Kathy herself, that her increased use of technology was related to her use of UCSMP materials. It is likewise just as reasonable to suppose that this factor was equally related to the content of the summer workshops that she had recently completed. Moreover, it seems likely that Kathy will begin to utilize technology in her UCSMP classes as she gains familiarity with the new materials. Certainly the intention to do so is there, as are the means.

Focus on applications. During an interview in November, Kathy described one of the two workshops she had attended that preceding summer:

One [workshop] was trying to bring real life situations into the various different courses. It's a two summer program, and next summer, they plan on splitting us up into content areas, and we would just work on making up lessons, using real-life situations.

This is a good fit with the UCSMP materials that she found herself implementing, as those materials also contain a focus on the practical applications of mathematics (UCSMP, 1989, p.4).

Kathy believes that applications play a significant role in her instruction, and she recognizes the motivational aspect of an applications approach. In a journal entry, she hypothesized:

If students can see where they can use things in real life, they are more willing to do the work.

As was the case with the instructional use of technology in Kathy's classroom, it is impossible to determine whether the changes she made in the way of an increased focus on the applications of mathematics are related to the UCSMP implementation or her participation in the summer workshop. Most likely, it is some combination of the two.

Constraints to change. From the beginning, I sensed that Kathy often felt pressed for time. This remained a source of frustration for her throughout the year. Compounding the issue of time management was her unfamiliarity with the innovative new instructional materials that she was using for the first time.

Kathy confirmed my interpretation that she often felt rushed during our first interview in September. Then, near the end of October, she wrote that:

There is frustration because there is so much to cover, and by the time I go over the homework, there isn't much time to work on the next lesson.

Later in that journal entry, the same theme surfaced in her account of the difficulties her students were encountering,

because there isn't enough time to go over the homework and read the next lesson in its entirety and students just do not finish the reading on their own.

My fieldnotes also contain frequent references to her being rushed or hurried. Clearly, time management was as significant a constraint for Kathy as it

was for Diane and Gina.

Kathy's unfamiliarity with the UCSMP materials was also inhibited her ability to make desired changes. Kathy first mentioned this in an informal discussion during my visit in December. My fieldnotes contain this account:

Kathy indicated during informal conversation that she believes that next year, she will be able to include a much greater use of technology in her *Algebra* classes than she is able to this year, due to her unfamiliarity with the new curriculum and materials. She also said that she expects to be better able to utilize the technology next year, when she has gained some familiarity with the new materials. I then asked her directly, "Do you feel constrained by the newness of the materials this year?" She answered, "Yes!"

Later during an interview, she told me:

In future years, I'll have an idea of what they're [her students] going to think.

Then I'll know how to handle it and be able to put something else in with it. /

think the first year of teaching anything is hard [emphasis added].

Without question, Kathy felt constrained by the lack of time and lack of familiarity with the UCSMP materials, particularly as she searched for the means to incorporate technology in her mathematics teaching.

Summary

The cases of Diane and Gina were the most alike. The sorts of changes in instructional practice that they both made imply a shift in their role as a teacher away from a transmission model of instruction toward a more constructivist model. In both cases, the ways in which the innovative UCSMP materials seemed to have facilitated changes in this direction were similar. These include:

- an increased use of cooperative learning strategies,
- the use of student reading as an instructional strategy,
- an increasing prominence for mathematical connections, and
- a transition toward the negotiation of shared meanings.

The case of Gina was similar to that of Kathy in that both developed an interest in the use of student projects as instructional devices. The other changes in Kathy's instructional practices were an increased interest in utilizing technology in instruction and the use of mathematical applications as a focus of instruction.

In all three cases, problems with time management in the implementation of the new materials and a lack of familiarity with those materials acted as constraints to change. Thus, the innovative UCSMP materials acted as both agents of and constraints to change in instructional practice for these three teachers.

Figure 1 summarizes the major points of change in the three cases, viewed in matrix form across cases.

Type of Change	DIANE	GINA	KATHY
1. cooperative groups	•		
2. student reading	•	•	
3. mathematical connections	•	•	
4. use of projects		•	•
5. use of technology			•
6. focus on applications			•
7. negotiation of shared meanings	•	•	
8. shifting role as teacher	•	•	

Figure 1: A Cross-Case Comparison of Interpretations and Findings

Discussion

As the process of change in instructional practice unfolded in the cases studied, a number of sources to which such change might be attributed suggested themselves. In the case of the use of reading as an instructional strategy and an increased attention to mathematical connections, the use of a UCSMP textbook seemed clearly to be the impetus for both Diane and Gina. The use of the UCSMP textbook seemed to be the source of Gina's greater use of cooperative learning strategies, as she strove to accommodate the UCSMP reading expectation with her ESL students. On the other hand, there seems to have been a different source of Diane's interest in and greater use of cooperative learning techniques. It is likely that the dialogue concerning cooperative learning which followed from Diane's interaction with the researcher during the first year of the study at least served as the catalyst for the changes that followed. Moreover, she seemed predisposed to make such a change.

The source of the transition toward the negotiation of shared meanings that was observed in both Diane and Gina is a bit more difficult to pin down. That perhaps follows from the more subtle nature of this change. One plausible explanation involves an interaction between cooperative learning activities and the use of the UCSMP textbook. As both of these teachers sought to develop their students' ability to make sense of what they were reading, and as they increasingly incorporated cooperative techniques, there was much more student-talk in their classrooms. This, in turn, increased the need for Diane and Gina to interpret what their students were saying. As it became increasingly clear to them that their students were indeed capable of constructing their own mathematical meanings, I

believe that a process of negotiation began to take root in each of their practices, perhaps unconsciously at first. At some point, however, I believe that each of them came to the realization that there was something powerful occurring in her classroom - something that was then consciously pursued.

The shift in teaching role that Diane and Gina were observed to make is also a subtle change, but I think more easily explained in light of the other changes that they were making. The use of cooperative learning strategies and the transition toward the negotiation of shared meanings both are more student-centered than teacher-centered activities. Thus, they cast the teacher in a different role, as a facilitator, rather than a teller or explainer. Moreover, if students are seen as able to read a mathematics textbook independently and make sense of it, there is less need for the teacher to provide and explain the mathematics content. This affords more opportunity for the teacher to facilitate an understanding of the content. Finally, as mathematical connections take a more prominent role in instruction, and as the teacher sees students actually making such connections, it is a natural step to see those students as capable of constructing meaning. This also supports the teacher's changing role in the classroom. Thus, the transformed role that was observed for both Diane and Gina was a natural extension of the other changes that they were making.

Most of the changes that Kathy made were different from those observed in Diane and Gina. The project orientation that Kathy espouses, particularly when set in contexts that are meaningful and of interest to students, suggests the sort of student-centered activities that may well, in time, also engender a shift in Kathy's role in the classroom. It seems clear that the primary source of the changes that

Kathy made was her participation in workshops during the summer immediately preceding the study. Because they are a good fit with the UCSMP philosophy and materials, it is plausible to conclude that Kathy's use of the UCSMP textbook supported an impetus to change that was rooted in her participation in those summer workshops.

It was shown that the innovative UCSMP materials did enable changes in instructional practice for Diane and Gina. In the case of Kathy, the UCSMP materials seem to have at least supported change in the areas where it was observed. It is interesting to note that the innovative materials also acted as a constraint to change, and that this constraining feature was observed in each of the three teachers. In all cases, however, the constraints were related to time management and unfamiliarity with the new materials. As the teachers gain experience with the innovation, in time these constraining factors may well disappear.

A number of recent studies of change in mathematics teachers' instructional practices have applied constructivist ideas to the problem of change in the practice of teaching mathematics (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989; Shaw & Jakubowski, 1991; Simon & Schifter, 1991; Wood, Cobb, & Yackel, 1991). From this perspective, teachers are seen as active problem solvers who construct and reconstruct their own understandings of the complex problems of teaching through an interactive process of interpretation. Fundamental to this position is the notion of perturbation, or a disturbance to the teacher's existing knowledge about teaching.

In the present study, it was found that the innovative UCSMP materials were an enabling factor in the process of change in teachers' instructional practices.

I believe that teachers' regular use of the Teacher's Editions of the UCSMP textbooks brought them into periodic contact with subtle hints and suggestions that are provided in the Teaching Notes that accompany each lesson in the textbook. These notes range over a variety of topics, including reading, making connections, small group work, alternative assessment, and extensions. Moreover, applications of mathematics are a focal point of the UCSMP textbooks, and the appropriate use of calculators and computers is assumed.

It is possible to account for the interpretation that the innovative UCSMP materials foster changes in teaching practice in a manner which is consistent with constructivist thinking. The teachers' daily interactions with the innovative textbook and materials required them to interpret the innovation on a regular basis. Quite possibly, such interactions provided a source of continuing perturbation in their understanding of their own practices.

If this analysis is correct, it carries a strong implication for those interested in effecting significant, fundamental changes in teaching practice. In addition to the classroom activities that a change initiative program might present to participants, a thoughtful, well-constructed set of written materials with which participants might regularly interact could provide a context for the sort of perturbation that can lead to thoughtful change.

It was also found that the innovative UCSMP materials sometimes acted to inhibit change in teaching practice. This constraint was manifested by time management problems that were often exacerbated by a lack of familiarity with the UCSMP materials. The pacing of lessons that is suggested by UCSMP, one lesson

per day with two or three days of review at the end of each chapter, seemed especially problematic for teachers.

It has been suggested that successful change initiatives require an adequate investment of time (Fullan, 1982, 1991; Schön, 1983). This may be related to the time management problems that were noted above. It may have been that the teachers simply lacked the time to adequately plan their uses of the unfamiliar UCSMP materials in ways that more efficiently managed the available instructional time. Moreover, it is precisely the unfamiliarity that may have been the culprit. Quite possibly, teachers who were using the new materials for the first time needed to work out the meaning of the innovation for themselves. Thus, they were left with insufficient time to adequately consider the problem of managing their own instructional time.

Once again this interpretation carries an implication for curriculum and textbook innovators. In large scale innovations, such as the district-wide implementation of an innovative textbook series, it is worth the investment in time and resources to provide contexts within which teachers might interact with and interpret the innovation *before* they are faced with the problem of implementation.

The ways in which the UCSMP textbook acted as an agent of or a constraint to change are summarized in Figure 2. Each is paired with an aspect of the UCSMP Secondary Component textbooks to which it might be related.

UCSMP as: An Agent of Change	Related Textbook Features
1. cooperative learning groups	Teaching Notes: Small group work
2. student reading	A major focus of UCSMP; Teaching Notes
3. mathematical connections	Teaching Notes: Making connections
4. applications of mathematics	A major focus of UCSMP
5. use of technology	Appropriate uses of calculators and computers written into the textbooks
6. use of student projects	Teaching Notes: Extensions
7. negotiation of shared meanings	A derivative of points 1, 2, 4, & 6
8. shift in teaching role	A derivative of points 1, 2, 4, 6, & 7
UCSMP as: A Constraint to Change	Related Textbook Features
1. time management	Lesson pacing suggested by UCSMP
2. unfamiliarity with the innovation	Lack of experience with the materials

Figure 2: Features of UCSMP Texts Enabling or Inhibiting Change

The results of this study carry a number of implications for further research. One of the conclusions reached nearly universally by those who study the problem of teacher change is that substantive change in teaching practice takes time. The case of Diane confirms this assertion. She continued to make changes in her practice of teaching during the second year of the study, and she herself anticipates that there is more change to come.

While some studies of change in mathematics teachers' instructional practices have covered more than one year, few studies of teacher change have used the same subjects throughout the 3 to 5 years that Fullan (1982, 1991) suggests are necessary to the change process. There is a need for such truly longitudinal studies.

The present study suggests that innovative textbooks and curriculum materials such as UCSMP both enable and inhibit change in teaching practice. If these materials can act to enable change in practice, and the results of this study indicate that they can, then it is important to learn which precise features of those materials actually enable and foster the change. This question is worthy of further investigation.

Conclusion

The sorts of changes envisioned by the current reform effort in school mathematics education, of which the NCTM Standards are a major part, will require most practicing teachers to make fundamental changes in their instructional practices. If we in academe are to play a significant role in bringing about such change, we are going to need a much deeper, more complete understanding of the process of change.

The process of teacher change has remained intractable partly due to its complexity and partly due to the methods by which evidence must necessarily be accumulated. Shulman's (1986) arguments favoring the development of a case literature in teacher education are persuasive and ought to be extended to the problem of teacher change. Only by subjecting to public scrutiny a wealth of data amassed in a variety of classrooms concerning a great number of teachers who are struggling with the process of change can we hope to come to an understanding of this process ourselves. Without such an understanding, the current reform effort in school mathematics education is likely to go the route of previous such efforts.

References

- Ball, D. L. & McDiarmid, W. G. (1988). Research on teacher learning: Studying how teachers' knowledge changes. *Action in Teacher Education*, 10(2), 17-23.
- Blumer, H. (1969). *Symbolic interactionism: Perspective and method*. Englewood Cliffs, NJ: Prentice-Hall.
- Bogdan, R. C. & Biklen, S. K. (1982). *Qualitative research for education: An introduction to theory and methods*. Boston: Allyn & Bacon.
- Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C. P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. *American Educational Research Journal*, 26(4), 499-531.
- Carrell, P. C., Pharis, B. G., & Liberto, J. C. (1989). Metacognitive strategy training for ESL reading. *TESOL Quarterly*, 23(4), 647-678.
- Coxford, A., Usiskin, Z., & Hirschhorn, D. (1991). *Geometry*. Glenview, IL: Scott Foresman.
- Fullan, M. G. (1982). *The meaning of educational change*. New York: Teachers College Press.
- Fullan, M. G. (1991). *The new meaning of educational change* (Second Edition). New York: Teachers College Press.
- Goldsmith, L. & Schifter, D. (1993). Characteristics of models for the development of mathematics teaching. In J. R. Becker & B. J. Pence (Eds.), *Proceedings of the Fifteenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, 2 (pp. 124-

130). San José, CA: Center for Mathematics and Computer Science Education, San José State University.

Hart, L. C. (1991). Assessing teacher change in the Atlanta math project. In R. G. Underhill (Ed.), *Proceedings of the Thirteenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education*, 2 (pp. 78-84). Blacksburg, VA: Virginia Tech.

Mathematical Sciences Education Board. (1990). *Reshaping school mathematics: A philosophy and framework for curriculum*. Washington, DC: National Academy Press.

McConnell, J. W., Brown, S., Eddins, S., Hackworth, M., Sachs, L., Woodward, E., Flanders, J., Hirschhorn, D., Hynes, C., Polonsky, L., & Usiskin, Z. (1990). *Algebra*. Glenview, IL: Scott Foresman.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics*. Reston, VA: Author.

Nelson, B. S. (1993, April). *Implications of current research on teacher change in mathematics for the professional development of teachers*. Paper presented at the annual meetings of the National Council of Teachers of Mathematics, 1 April 1993, Seattle, WA.

Olson, J. K. & Eaton, S. (1987). Curriculum change and the classroom order. In J. Calderhead (Ed.), *Exploring teachers' thinking* (pp. 179-194). London: Cassell.

Richardson, V. (1990). Significant and worthwhile change in teaching

practice. *Educational Researcher*, 19 (7), 10-18.

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action*. New York: Basic Books.

Shavelson, R. J. & Stern, P. (1981). Research on teachers' pedagogical thoughts, judgments, decisions, and behavior. *Review of Educational Research*, 51(4), 455-498.

Shaw, K. L., & Jakubowski, E. H. (1991). Teachers changing for changing times. *Focus on Learning Problems in Mathematics*, 13(4), 13-20.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher*, 15(2), 4-14.

Simon, M. A. & Schifter, D. (1991). Towards a constructivist perspective: An intervention study of mathematics teacher development. *Educational Studies in Mathematics*, 22, 309-331.

Sinclair, H. (1990). Learning: The interactive recreation of knowledge. In L. P. Steffe & T. Wood (Eds.), *Transforming children's mathematics education: International perspectives* (pp. 19-29). Hillsdale, NJ: Lawrence Erlbaum.

The University of Chicago School Mathematics Project. (1989). *UCSMP secondary component*. Chicago, IL: Author.

Usiskin, Z., Flanders, J., Hynes, C., Polonsky, L., Porter, S., & Viktora, S. (1989). *Transition Mathematics* (Teacher's Edition). Glenview, IL: Scott Foresman.

Wood, T., Cobb, P., & Yackel, E. (1991). Changes in teaching mathematics: A case study. *American Educational Research Journal*, 28(3), 587-616.